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Exchange Rate as a Determinant of Corporate Loan Defaults in a Euroized Economy: Evidence from Micro-Level Data

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This article examines the factors that induce nonperformance of loans in an economy with a high degree of currency substitution. Using a well-diversified portfolio of corporate loans from a Serbian bank between 2008 and 2012, we find three key determinants of loan default: exchange rate, lagged GDP growth rate, and loan size. Exchange rate depreciation is associated with an increase in the default rate whether the loan is denominated in foreign or local currency. By controlling for positive effects on revenue, we show that this finding can be attributed to an increase in the firms' net input costs due to the depreciation.

Keywords: credit risk, macroeconomic determinants, nonperforming loans

JEL Classification: G21, G32

Credit performance has a broad impact on the entire economy in that it may drive both firms and banks into a vicious cycle of declining profitability, and possibly into a recession. Hence, understanding the drivers and determinants of credit default is of paramount importance for financial institutions and regulators alike. The global financial crisis of 2007–2009 was accompanied by a notable deterioration of credit performance in many countries. In particular, the post-crisis level of nonperforming loans (NPLs) rose sharply in many emerging-market economies. Klein (2013) reports that in Central, Eastern, and Southeastern Europe (CESEE), the fraction of NPLs as a share of total credit increased from 3 to 11 percent between 2007 and 2011. This increase was accompanied by a relatively high variation in the share of NPLs in total credit

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across the countries. At the end of 2011, it ranged from 4 percent for Estonia to 19 percent for Serbia. The rise in NPL ratios is also widespread across banks and borrower types.

There is significant empirical evidence regarding anti-cyclical behavior of default rates, as shown by Berge and Boye (2007), Fofack (2005), Jiménez and Saurina (2006), Rajan and Dhal (2003), Salas and Saurina (2002), and many other authors. It is not surprising that the economic cycle drives loan performance. The usual theoretical explanation is that higher real GDP growth induces more income, thereby improving the debt repayment capacity of borrowers. Conversely, when there is a slowdown in the economy, borrowers face greater difficulties in repaying their debt, thus increasing the NPL ratio. The classical literature on interactions between the macroeconomic environment and financial fundamentals goes back to the models developed by Bernanke and Gertler (1989), Bernanke, Gertler, and Gilchrist (1998), King and Plosser (1984), Kiyotaki and Moore (1997), and Pesaran, Treutler, and Weiner (2006), who developed a framework that links the changes in value of a credit portfolio to a dynamic global macroeconometric model, and conclude that the relationship between firms and the business cycle is the main driver of defaults.

The high variability in the post-crisis levels of NPLs in emerging markets, both between and within countries, points to other factors in addition to GDP. Macroeconomic variables that may affect banks' asset quality include exchange rates, real interest rates, unemployment, and inflation (Berge and Boye 2007; Boss 2002; Louzis, Vouldis, and Metaxas 2010; Nkusu 2011), as well as various measures of the overall indebtedness of firms, such as ratio of credit to GDP (Jakubik and Schmieder 2008) or of external debt to GDP (Vogiazas and Nikolaidou 2011).

Exchange rate depreciation may have a negative impact on asset quality, particularly in countries with substantial amounts of foreign-currency lending to unhedged borrowers. Higher interest rates affect the debt-servicing ability of borrowers, especially in the case of floating-rate loans. Higher unemployment directly reduces the repayment ability of retail borrowers. Corporate credit performance may also be affected indirectly through reduced profitability due to income effect on households. The impact of inflation, however, may be ambiguous. On one hand, higher inflation can make debt servicing easier by reducing the real value of outstanding loans, but on the other hand, it can also decrease the borrower's real income in the presence of nominal rigidities. Higher inflation can also lead to an increase in interest rates resulting from contractionary monetary policy (Nkusu 2011). Several studies have also found that NPLs are affected by the prices of stocks and housing units, attributing defaults to wealth effects and declines in collateral value. Simons and Rolwes (2009) found that the default behavior of Dutch firms is influenced by GDP growth, oil prices, and, to a lesser extent, interest and exchange rates.

In addition to macroeconomic factors, the literature also identifies several bank-specific determinants of the evolution of NPLs over time. These include such factors as cost efficiency (e.g., Berger and DeYoung 1997; Louzis, Vouldis, and Metaxas 2010; Podpiera and Weil, 2008; Rossi, Schwaiger, and Winkler 2005; Williams 2004) and/or moral hazard in banks with low levels of capital (Berger and DeYoung 1997; Jiménez and Saurina 2006; Keeton and Morris 1987; Salas and Saurina 2002). Using Moody's database of corporate bond defaults during 1981–2002, Figlewski, Frydman, and Liang (2006) found that the intensity of the occurrence of credit events was strongly influenced by both macroeconomic and issuer-specific factors. Interestingly, the specific factors become very robust only after macroeconomic variables are added to the model.

In this article, we will focus on the impact of exchange rate fluctuations on default rates in an economy with a high degree of currency substitution. Intuitively, in such an economy, any depreciation of the local currency should weaken the repayment ability of borrowers. In addition, we investigate whether the impact of the exchange rate on default risk is more important for foreign-currency loans than for loans denominated in local currency. We use an original database of micro-level data on individual loans from a systemically relevant bank in Serbia, a highly euroized economy that applies a managed float currency regime.[1]

The remainder of the article is organized as follows. The second section discusses the macroeconomic background of our research, with an overview of the main economic developments in Serbia during the period covered by our data. Next, we present the dataset used in the article, explain the construction of the variables used in the model, and then present and discuss the empirical results. Concluding remarks, as well as the practical and policy implications of the findings, follow.

MACROECONOMIC BACKGROUND

The high euroization in CESEE is usually perceived as a significant source of systemic risk (EBRD 2010; Klein 2013). With the opening of capital markets and financial integration driven by the entry of foreign banks, financial euroization extended to the liability side of both households and firms. Although cross-border financing was a principal driver of long-term growth in transition economies, it also fueled a large credit expansion that was brought to an abrupt halt by the global financial crisis (EBRD 2009). The sources of financing are usually based in the countries of origin of locally active banking groups, resulting in loans that are typically denominated in the base currencies of the mother banks rather than local currencies. As an illustration, in Table 1 we show the fraction of foreign-currency loans in the CESEE countries in 2012 as a percentage of the total amount of loans issued by local banks to households and firms.

Financial euroization on such a wide scale may be problematic from both a macroeconomic and a financial-stability perspective for two principal reasons. First, in countries with a floating currency regime and independent monetary policy, a high level of euroization reduces the effectiveness of inflation or price-level targeting. Since foreign-currency loans are mostly priced using a euro area benchmark rate rather than a local currency reference rate, euroization reduces the power of the interest rate channel. Second, a high share of loans in foreign currency exposes unhedged borrowers to exchange-rate risk. As Breuer et al. (2010) show, exchange-rate risk may spill over to higher credit exposure of banks and other lenders. As Calvo and Mishkin (2003) show, the latter also puts limitations on the flexibility of the exchange rate: the greater the fraction of unhedged foreign-currency borrowers, the higher the public pressure against depreciation. This reduces the ability of the economy to absorb shocks. On the other hand, once depreciation occurs, it exacerbates financial fragility and increases the capital needs of the banking sector through higher loan loss provisions. Depreciation episodes usually coincide with periods of capital outflow that are adding contractionary pressures to the overall economic activity. Moreover, the high pass-through of foreign exchange rate on prices indirectly reduces the purchasing power and disposable income of economic agents (see Beirne and Bijsterbosch 2009; Mladenović and Petrović 2014), thereby reducing the debt-repayment capacity of local-currency borrowers as well.

TABLE 1
Financial Euroization in Emerging Europe: Share of Foreign Currency to Total Loans Issued to Households and Firms in 2012 (percentage of total amount outstanding)

Central Europe and the Baltics	
Croatia	72.2
Hungary	55.4
Latvia	87.3
Lithuania	73.4
Poland	32.6
Southeastern Europe	
Albania	64.5
Bosnia and Herzegovina	66.8
Bulgaria	63.8
FYR Macedonia	57.4
Romania	63.6
Serbia	72.2
Eastern Europe and the Caucasus	
Armenia	64.2
Azerbaijan	33.6
Belarus	42.3
Georgia	68.2
Moldova	43.3
Ukraine	39.9

Source: EBRD (2012).

Currency substitution in Serbia is partly a legacy from the history of several hyperinflation episodes before the economic transition, resulting in a widespread habit of saving in foreign currency. The local currency, the Serbian dinar (RSD), is now predominantly substituted by the euro in business transactions and used for the denomination of a large fraction of financial assets and liabilities. In the period before the global financial crisis, Serbia experienced strong economic growth, with an average growth rate of 5 percent between 2002 and 2008. This was paralleled by substantial financial inflows, mostly intermediated through foreign banks in Austria, Italy, France, and Greece, which entered the market and established their subsidiaries. The result was an annual growth rate of bank credit to businesses of around 30–40 percent. In addition, direct cross-border loans to Serbian companies emerged on a wider scale in 2006. The consolidated measure of credit to GDP, including both local and direct cross-border loans, was 72 percent at the end of 2008. The initial impact of the crisis in Europe created a sudden liquidity drain and ceased most of the financial inflows. This induced higher-risk premiums with respect to the pre-crisis levels.

In Serbia, as in most of the other CESEE countries that apply a floating currency regime, a significant currency depreciation accompanied the crisis. Between 2008 and 2012, the Serbian dinar lost about 40 percent of its value with respect to the euro (Figure 1). The ratio of nonperforming to total loans of the banking sector soared from its pre-crisis level of 10 percent to 20 percent in 2012. The eurozone public debt crisis of 2010 brought additional

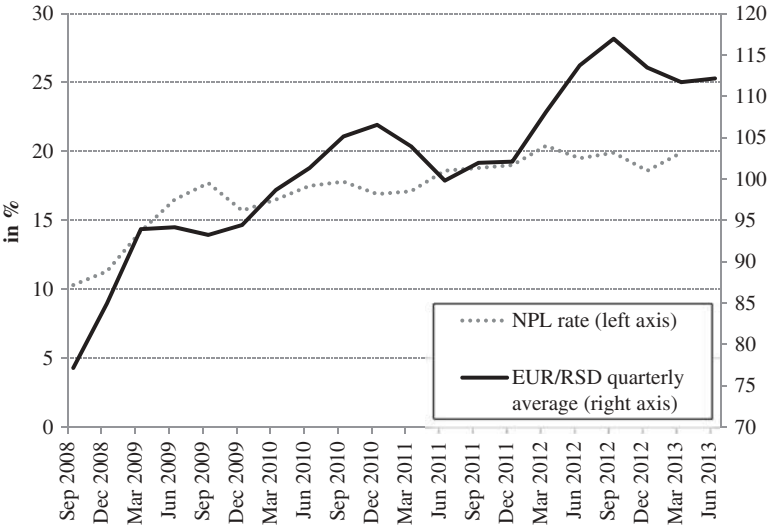

FIGURE 1 EUR/RSD Exchange Rate and NPL Development Since the Global Financial Crisis.
Source: National Bank of Serbia

financial pressure to locally active banks with foreign capital. Liquidity concerns and capital shortages in their headquarters banks reduced the refinancing capacity of local subsidiaries and raised funding costs. Credit growth continued until the end of 2012, but its pace was reduced below the 10 percent level. With fiscal policy efforts to stimulate bank credit, launch large infrastructure projects, and attract foreign direct investments, Serbia's GDP barely recovered from a sharp 3.5 percent contraction in 2009, reaching modest growth rates of 1 percent and 1.6 percent in 2010 and 2011, respectively. This recovery was weak and unsustainable, as GDP contracted again by 1.7 percent in 2012, bringing the economy to a double-dip recession.

Currency depreciation pressures still remain as a consequence of large structural imbalances. The record-high current account gap of 21 percent of GDP in 2008 was financed by foreign inflows into the financial sector; in contrast, the post-crisis level of 8 percent of GDP was largely covered through the issue of government debt securities. As Figure 1 indicates, loan performance in Serbia seems to go hand-in-hand with currency depreciation. The purpose of this article is to investigate this relationship more closely.

DATA AND VARIABLES

For the purposes of the present research, we are using a unique database from a representative bank in Serbia that consists of a pooled panel of loans to companies and entrepreneurs over the five-year period between 2008 and 2012. The length of the data series satisfies the Basel regulatory compliance standard of a minimum of five years (BCBS 2006). We

combine our loan data with firm-level characteristics obtained from the Register of Financial Statements from the Serbian Business Registers Agency, as well as the firm-level data on annual exports and imports of goods obtained from the Customs Administration of the Republic of Serbia.

The level of observation is an individual loan contract i in year t. As each loan may be repaid over a period extending beyond a single year, the overall estimation sample consists of 16,279 loan-year observations. Since a borrower may have more than one loan, and borrow more than once within the observed five-year period, the estimation sample covers 9,835 distinct individual borrowers. We have eliminated the outliers and obvious errors in the original data input from the database.[2] Furthermore, we have confined our estimation sample to loans denominated only in euros and Serbian dinars.[3] Loans denominated in Swiss francs, which was another currency being used for indexation of loans,[4] with the variable interest rate linked to CHF-LIBOR have been excluded in order to isolate the effect of a single exchange rate and avoid working with intercurrency rates.[5]

The observed bank is a foreign-owned universal bank operating in Serbia since 2003. The bank entered the market following the restructuring of the banking system, as did many other banks with predominantly foreign capital. These banks are now among the leading players in the local market. Over the period of observation, the observed bank was represented with an approximately 6 percent share in all the loans offered to businesses in Serbia. The bank was among the top ten banks in Serbia during the observed period. The Serbian banking sector is characterized by a relatively low level of concentration, with thirty-four licensed banks in 2008 and thirty-one in 2012. At the same time, the business sector in Serbia is relatively highly concentrated, consisting of some 100,000 companies, with the top 500 creating 52 percent of the total turnover during 2011 (Atanasijević and Ilić 2012). This translates into a structure where most of the large and medium-sized companies have relations with all the major banks and where companies usually borrow from more than one bank.

Our database consists of a set of variables for each loan-year in the bank's portfolio. The variables include loan characteristics, borrower characteristics, and macroeconomic data. If the loan was fully repaid during the observation period, it was automatically removed from the database for all subsequent years. Each loan with payment arrears was tracked through the number of days since it became past due, denoted by *DaysPastDue*. Our main dependent variable is the nonperformance indicator, denoted by *NPL*, equal to 1 for loans overdue for ninety days or more, and zero otherwise. During the period of observation, there were no transfers of overdue loans out of the portfolio (e.g., through the sale of receivables), implying that a loan can theoretically leave the nonperforming status by reestablishing a regular repayment. Among independent variables, the one of particular interest is the variable tracking the euro exchange rate with respect to the local currency. This variable, denoted by ΔX_t, was constructed as an index that measures the appreciation of the euro from the date of loan disbursement to the moment of observation (year-end for the respective year).

The remaining independent variables were constructed to control for other credit-risk determinants with a meaningful theoretical or empirical ground, while avoiding collinearity. These are: GDP growth rate lagged by a year; loan size relative to the firm's total assets; percentage of

TABLE 2
Definition of Variables and Descriptive Statistics

Variable name	*Def.*	*M*	*SD*	*Min*	*Max*	*Freq. of 1s (for dummy variables) in %*
$DaysPastDue_{i,t}$	Number of days past due for loan i in year t	69.03	227.21	0	2436	
$NPL_{i,t}$	Indicator function, equal to 1 if $DaysPastDue_{i,t} \geq 90$, and 0 otherwise					12.55
ΔX_t	Index of change in EUR/RSD rate from date of loan disbursement to date of portfolio observation	109.04	9.89	95.80	181.72	
g_{t-1}	Annual GDP growth rate, one-year lag	1.71	3.06	–3.50	5.40	
$RelLoanSize_{i,t}$	Outstanding amount of loan i relative to firm's total assets in year t	0.09	0.13	0.00	1.00	
$CollateralCov_{i,t}$	Percentage of outstanding amount of loan i covered by eligible collateral in year t	27.50	43.60	0.00	127.42	
$RelFirmSize_{i,t}$	Total assets of firm with loan i relative to total assets of all firms in economy in year t (%)	0.0046	0.0394	0.00	1.9143	
$InterestRate_i$	Initial interest rate on loan i (%)	6.60	5.92	0.00	26.00	
$Region_{i,t}$	Dummy variable, equal to 1 if firm with loan i operates in capital in year t; 0 otherwise					29.82
$Relationship_{i,t}$	Dummy variable, equal to 1 if firm with loan i has current account with bank in year t; 0 otherwise					99.55
$NetExporter_{i,t}$	Dummy variable, equal to 1 if firm with loan i is net exporter in year t; 0 otherwise					9.84
$BothCurr_{i,t}$	Dummy variable, equal to 1 if firm with loan i had loans in both EUR and RSD in year t; 0 otherwise					68.55
$LoanEUR_i$	Dummy variable, equal to 1 if loan i is denominated in EUR; 0 if denominated in RSD					56.53

the initial loan amount covered by eligible collateral, where the haircut has been applied based on the bank's internal policy, including a conservative approach to valuation, time to cash, and collection of transaction cost; relative size of the firm, measured as the value of its assets divided by the sum of the total assets of all the firms in the economy in a given year; interest rate at loan disbursement; regional dummy, equal to 1 if the firm operates in the capital city, and zero otherwise; relationship dummy, equal to 1 if the firm had an account with the bank prior to loan disbursement; an indicator of whether the firm was a net exporter in a given year; and an indicator of whether the firm had loans in both currencies in a given year. Definitions of the variables and their descriptive statistics are given in Table 2. Other details, such as structure of NPLs by loan denomination currency, number of observations by year, and borrower structure by currency are shown in Tables 3 to 5.

TABLE 3
Structure of Loans by Denomination Currency

(*a) Performing vs. nonperforming loans*

	EUR-denominated	*RSD-denominated*	*Total*
Performing	7,904	6,332	14,236
Nonperforming	1,299	744	2,043
Total	9,203	7,076	16,279

(b) Other descriptive statistics

	EUR-denominated	*RSD-denominated*	*Full sample*
Loan age (mos.)	19.5 (17.7)	12.5 (11.1)	16.5 (15.6)
Loan size (% of total assets)	12.7 (15.7)	3.4 (6.5)	8.7 (13.4)
Collateral coverage (% of loan size)	44.6 (47.8)	5.2 (22.9)	27.5 (43.6)
Initial interest rate (%)	8.03 (2.69)	4.75 (8.08)	6.60 (5.92)

Notes: Sample averages. Standard deviations in parentheses.

TABLE 4
Number of Observations by Year

Year (t)	*2008*	*2009*	*2010*	*2011*	*2012*	*Total*
Observations (*i*)	3,363	3,505	3,306	3,079	3,026	16,279
Individual borrowers	1,967	2,119	1,999	1,904	1,846	9,835

TABLE 5
Borrower Structure by Currency

Year (t)	*2008*	*2009*	*2010*	*2011*	*2012*	*Total*
Borrowers with RSD loans only	817	584	682	607	498	3,188
Borrowers with both RSD and EUR loans	506	510	452	417	382	2,267
Borrowers with EUR loans only	644	1025	865	880	966	4,380
Total number of borrowers	1,967	2,119	1,999	1,904	1,846	9,835

EMPIRICAL RESULTS

To assess the determinants of NPLs, we use the following general specification:

$$DaysPastDue_{it} = \beta_0 + \beta_1 \Delta X_t + \beta_2 g_{t-1} + \beta_3 RelLoanSize_{it} + \beta_4 CollateralCov_{it} + \beta_5 RelFirmSize_{it} + \beta_6 InterestRate_i + \beta_7 Region_{it} + \beta_8 Relationship_{it} +,$$
$$NPL_{it} = 1_{\{DaysPastDuei,t90\}}$$

where the subscript $i = 1, 2, \ldots, N$ counts the individual loans, $t = 1, 2, \ldots, T$ labels the time periods, while 1 stands for the indicator function. We consider three samples: the full dataset, the subsample of EUR-denominated loans, and the subsample of RSD-denominated loans (cf. Table 3). Fisher's exact test on the subsamples shows a p-value of less than 10^{-4}, indicating a

TABLE 6
Probit Model: Beta Coefficients

$NPL_{i,t}$	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t	0.0537***	0.0419***	0.0893***
	(0.0019)	(0.0021)	(0.0037)
g_{t-1}	–0.0377***	–0.0430***	–0.0367***
	(0.0037)	(0.0047)	(0.0068)
$RelLoanSize_{i,t}$	1.0978***	1.0023***	1.836***
	(0.1299)	(0.1337)	(0.3075)
$CollateralCov_{i,t}$	0.0016***	0.0016***	0.0050***
	(0.0005)	(0.0005)	(0.0011)
$RelFirmSize_{i,t}$	0.1964	0.2881	–0.6967
	(0.3448)	(0.3817)	(1.2431)
$InterestRate_i$	0.0130***	0.0122	0.0233***
	(0.0032)	(0.0111)	(0.0040)
$Region_{i,t}$	0.1240***	0.1430**	0.1467**
	(0.0436)	(0.0570)	(0.0659)
$Relationship_{i,t}$	0.0131	–0.1635	0.3622
	(0.2611)	(0.3024)	(0.4768)
$NetExporter_{i,t}$	0.0429	0.0575	0.0473
	(0.0527)	(0.0682)	(0.0822)
$BothCurr_{i,t}$	–0.1422***	–0.0800	–0.2185***
	(0.0423)	(0.0567)	(0.0618)
$LoanEUR_i$	–0.2554***		
	(0.0495)		
Observations	16,279	9,203	7,076
Wald χ^2	1,250.61	822.64	734.29
Pseudo-R^2	0.1961	0.1629	0.2930

Notes: Clustered standard errors are given in parentheses, with clustering by individual loan contracts. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance levels, respectively.

structural difference between EUR- and RSD-denominated loans.[6] This difference is partly a consequence of the fact that the two currency denominations typically go hand-in-hand with the loan type: RSD loans are predominantly short-term liquidity loans with little or no collateral coverage, while EUR loans are mostly medium- and long-term investment loans that are better collateralized, on average (see also Table 3(b)). Thus, to run the model, we will either use a dummy for currency of denomination in the full sample or work with the subsamples split by the currency. The splitting makes the separation of loans by type unnecessary, allowing us to focus on the impact of the exchange rate in the analysis of results.

We start the analysis with a pooled probit model applied on NPL_{it}. Tables 6 and 7 summarize the estimation results. Table 6 reports the beta coefficients, while Table 7 shows the marginal effects. We apply clustered standard errors in all estimations, using individual loan contracts as clusters. Since the portfolio is well diversified, we assume that the observations are independent across the clusters, but allow for correlations across periods within the same cluster.

There are several results that hold consistently in all the samples. The coefficient corresponding to exchange rate difference ΔX_t is always positive and highly significant. Therefore, depreciation of the local currency with respect to the euro contributes to the increase in default

TABLE 7
Probit Model: Marginal Effects

$NPL_{i,t}$	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t	0.0087***	0.0078***	0.0108***
	(0.0004)	(0.0005)	(0.0006)
g_{t-1}	–0.0061***	–0.0080***	–0.0044***
	(0.0006)	(0.0009)	(0.0009)
$RelLoanSize_{i,t}$	0.1785***	0.1861***	0.2219***
	(0.0210)	(0.0247)	(0.0377)
$CollateralCov_{i,t}$	0.0002***	0.0003***	0.0006***
	(0.0001)	(0.0001)	(0.0001)
$RelFirmSize_{i,t}$	0.0319	0.0535	–0.0842
	(0.0561)	(0.0709)	(0.1500)
$InterestRate_i$	0.0021***	0.0023	0.0028***
	(0.0005)	(0.0021)	(0.0004)
$Region_{i,t}$	0.0209***	0.0276**	0.0185**
	(0.0076)	(0.0114)	(0.0087)
$Relationship_{i,t}$	0.0021	–0.0335	0.0330
	(0.0417)	(0.0677)	(0.0311)
$NetExporter_{i,t}$	0.0071	0.0110	0.0059
	(0.0090)	(0.0134)	(0.0105)
$BothCurr_{i,t}$	–0.0240***	–0.0152	–0.0280***
	(0.0074)	(0.0110)	(0.0083)
$LoanEUR_i$	–0.0425***		
	(0.0083)		
Observations	16,279	9,203	7,076
Wald χ^2	1,250.61	822.64	734.29
Pseudo-R^2	0.1961	0.1629	0.2930

Notes: Clustered standard errors are given in parentheses, with clustering by individual loan contracts. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance levels, respectively.

rate, *irrespective of the currency of denomination*. Moreover, it does not seem to be more pronounced for the foreign-currency loans. The marginal effects indicate that an increase in the exchange rate by one unit, while other explanatory variables take their average values, results in the default rate going up, on average, by 1.08 percentage points for RSD-denominated loans, but only 0.78 percentage points for EUR-denominated loans. Overall, a marginal increase in the EUR/RSD exchange rate leads to an increase of 0.87 percentage points in the default rate of the entire portfolio. The fact that the exchange rate affects EUR and RSD loans in a similar way can also be seen from the first panel in Figure 2, which shows predicted nonperforming probabilities for different levels of ΔX_t: the lines that correspond to RSD-denominated loans (solid blue line) and EUR-denominated loans (dashed red line) are very close to each other, while the 95 percent confidence intervals practically overlap.

The lagged GDP growth rate, g_{t-1}, is highly significant and negative in all the samples. The marginal effects of an additional percentage-point decline in growth leads, on average, to an increase of the default rate in the following year by 0.61 percentage points. For EUR-denominated loans, the expected decline is 0.80 percentage points, and for RSD-denominated loans it is 0.44 percentage points. The second panel in Figure 2 illustrates predicted nonperforming

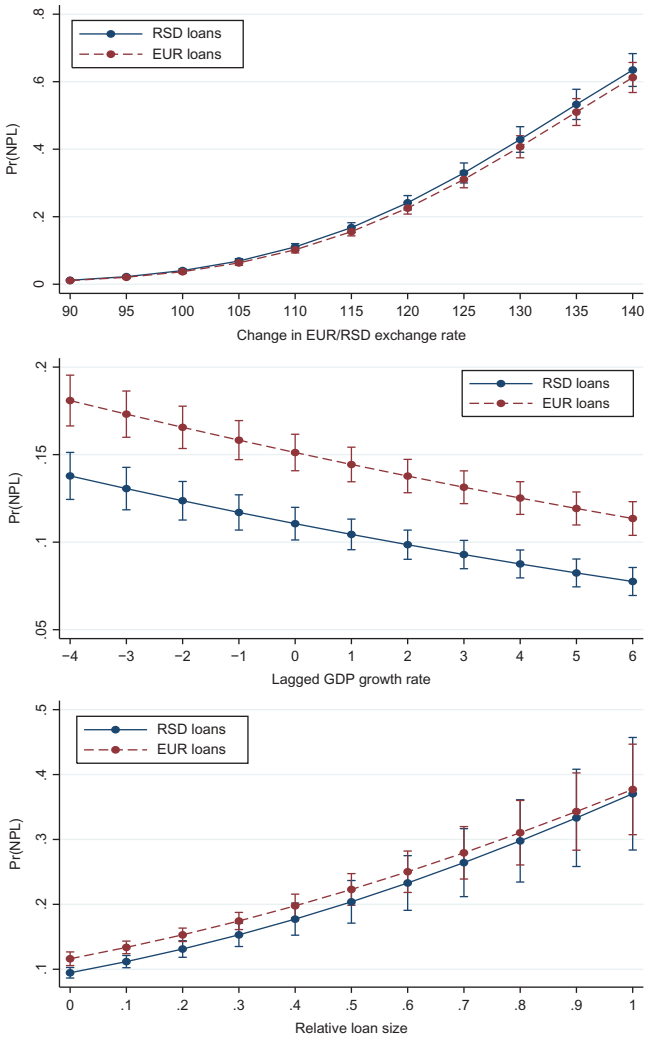

FIGURE 2 Probit Model: Predicted NPL Probabilities for Different Levels of Relative Change in EUR/RSD Exchange Rate, Lagged GDP Growth Rate, and Relative Loan Size.

probabilities for different levels of lagged GDP growth rate. The graph that corresponds to EUR-denominated loans (dashed red line) has a slightly steeper decline than the one for RSD-denominated loans (solid blue line). The negative relationship between lagged GDP growth rate and loan default is consistent with the anti-cyclical behavior of NPLs discussed in the literature (see the first section). The lagged GDP growth rate has a higher impact than the *contemporaneous* GDP growth rate, g_t, as it takes some time for economic downturn to feed

back. Similar findings have been reported by Jiménez and Saurina (2006), who performed their analysis on the Spanish Central Credit Register database. The alternative model, where contemporaneous GDP growth rate is used as an explanatory variable, results in the marginal effect of g_t being only about a half of the one found for g_{t-1}.

Size of loan relative to the firm's total assets, $RelLoanSize_{i,t}$, is highly significant and positive. The intuition is that more leveraged companies are less likely to pay off their debt. In principle, an increase in leverage may lead to several issues for a company. First, it has less capital to buffer potential losses from its riskier projects, making it less stable and more prone to credit risk. Second, the company may become more financially constrained than a comparable firm with a lower level of debt, which makes liquidity management more difficult. Third, as Jensen and Meckling (1976) show, high-leverage firms are more likely to undertake riskier projects, even those with a negative net present value. It is worth noting that the impact of relative loan size is greater for RSD loans: a percent increase in the loan size relative to total assets leads, on average, to an increase of 0.22 percentage points in the default rate; the corresponding increase for EUR loans is 0.19 percentage points. This is mostly a consequence of the predominant lack of collateral coverage in the subsample of RSD loans: unlike the majority of the EUR-denominated loans, only the larger ones in the local currency are collateralized.[7] The positive association between increased leverage and default rate can be seen from the third panel in Figure 2, which shows the predicted nonperforming probabilities for different levels of relative loan size, ranging from 0 to 1. For smaller loans, the slopes of the two graphs that correspond to EUR and RSD loans are very similar. As the loan size increases relative to the firm's total assets, the slope becomes greater for the RSD loans (solid blue line), indicating a stronger relationship between leverage and default than for the EUR loans (dashed red line), since the latter become better collateralized at higher values of $RelLoanSize_{i,t}$.

Probit estimates indicate that the percentage of loan initially covered by collateral ($CollateralCov_i$) is negatively associated with loan performance. A standard theoretical argument for use of collateral is its power in reducing problems of moral hazard. The fear of losing the assets pledged as collateral increases the borrower's incentives to take costly actions that may improve the likelihood of repayment (e.g., Besley and Ghatak 2010); Boot, Thakor, and Udell 1991; Innes 1990). In addition, a company may provide better collateral or other forms of risk-mitigating instruments, such as a guarantee, if it was not financially constrained in the first place. Typically, company loans are secured by financial collateral, commonly in the form of a deposit or a bill, rather than nonfinancial collateral, such as a mortgage on nonresidential real estate. Our probit results for collateral coverage are thus counterintuitive, but as it turns out, the relationship is not robust. Most likely, it originates from a positive relationship with the loan currency, since EUR loans are better collateralized.

We do not find any association between firm size and loan-repayment ability, as the beta coefficients of $RelFirmSize_{i,t}$ are not significant in any of the samples. This is in contrast to some previous findings in the literature. For instance, Beck et al. (2006) find that larger firms encounter fewer obstacles in obtaining credit from banks because they generate larger cash flows and control more collateralizable assets.[8]

To control for *ex-ante* credit risk, we use the loan interest rate at time of loan disbursement, $InterestRate_i$. If the bank perceived a loan as riskier, the initial interest rate would be higher. The variable is highly significant for RSD loans and in the full sample. A possible interpretation is related to the structure of RSD loans. They have lower interest rates, on average, but are more

diverse in terms of initial credit risk.[9] In other words, the RSD subsample consists of loans to very heterogeneous borrowers, and some of them represented a substantial credit risk for the portfolio from the moment they were issued. This also probably indicates that these firms faced liquidity issues.

The distance and relationship between the company and the bank may also be an important factor, as shown by DeYoung, Glennon, and Nigro (2008) and Geršl and Jakubík (2011). Here we find that the companies operating in the capital ($Region_i = 1$) have significantly lower odds of repaying their loans. A possible explanation is that the bank's local branches in smaller towns are better at screening and monitoring their clients, and that the clients take into account the greater reputational risk associated with a potential default. On the other hand, we cannot corroborate that the companies that were the bank's clients during the lifetime of a loan have better creditworthiness, since the estimates of beta coefficients corresponding to the $Relationship_{i,t}$ dummy are insignificant.

It is important to focus on the economic mechanisms through which depreciation of the dinar with respect to the euro contributes to increase in NPLs. The influence of the exchange rate on credit risk appears to be unrelated to the currency of denomination of the loan, even after controlling for other macroeconomic, borrower-specific, and loan-specific factors such as GDP growth rate, loan size, collateral coverage, age of the loan, credit risk, firm size, and the firm's location and relationship with the bank. We attribute this finding to the fact that the first-order effect of the exchange rate depreciation is through an increase in the company's input costs and overall liabilities, rather than through a direct impact on the borrower's ability to repay a particular loan. As discussed above, changes in the exchange rate translate, possibly with a certain lag, to the overall price level. Additionally, the pass-through of exchange rate to prices is significant (Figure 3). Moreover, periods marked with sharp depreciation of the dinar with respect to the euro are usually followed by an increase in the local-currency reference rate, irrespective of the phase of the economic cycle. This follows from monetary policy concerns over prices. The local interest rate has a more indirect role in preventing carry-trade outflows and stronger currency depreciation than in affecting aggregate demand and prices. At the same time, in an economy with a high degree of currency substitution, an increase in the exchange rate should affect the company's profitability and outweigh the negative effect on input costs. If that was indeed the case, the positive effect should be more pronounced for exporting firms. However, this does not seem to hold for the firms in our sample: the $NetExporter_{i,t}$ dummy turns out to be insignificant, indicating that any potential increase in income due to local-currency depreciation is of secondary importance. The net importing companies are more likely to fall in arrears due to EUR appreciation with respect to RSD. To measure the existence and extent of this effect, we include the interaction term between the $NetExporter_{i,t}$ dummy and exchange-rate appreciation ΔX_t. In all three samples, the beta coefficients of the interaction term are insignificant.[10] This shows that importing companies are neither more nor less likely to suffer from a default risk induced by appreciation of the euro.

Another characteristic of corporate debt that may be relevant for interpreting the relationship between payment ability and the exchange rate is that a company relying on external financing typically has more than one loan. These loans may be in EUR, RSD, or both. In fact, around 23 percent of the borrowers in the sample have loans in both currencies during the period of observation (cf. Table 5). The ability to borrow in both currencies seems to be an indicator of better repayment capacity: the dummy variable that captures whether a company

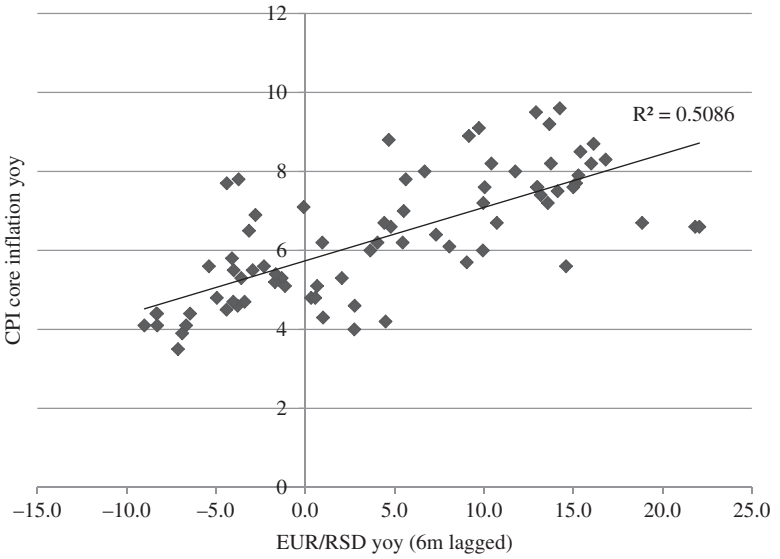

FIGURE 3 Inflation and Exchange Rate, January 2007–June 2013.
Notes: Growth refers to depreciation, contraction to appreciation. Core inflation excludes energy, food, alcohol, and cigarettes from the overall CPI index. The core CPI data are available only from January 2007.
Source: National Bank of Serbia

borrows from the bank in both currencies, $BothCurr_{i,t}$, is significant and has a negative coefficient for the full sample and for the RSD loans. Finally, the loan currency in the full sample is significant, and the beta coefficient of $LoanEUR_i$ is negative. In other words, EUR loans were, on average, less likely to default during the observation period. This result is again probably related to the difference in the structure of EUR and RSD loans in our sample, as non-indexed loans have worse collateral coverage and were predominantly used to finance short-term liquidity needs.

To verify our major results, we also run a regression where the number of days past due is used as the dependent variable. Since $DaysPastDue_{i,t}$ is an integer variable, we apply Poisson regression for panel count data.[11] The results are summarized in Table 8. As with the probit model, the exchange rate, lagged GDP growth rate, relative loan size, borrowing in both currencies, and currency dummy remain highly significant, maintaining their respective signs. The results in Table 8 show that depreciation of the local currency by 25 percent during the lifetime of a loan (say, from around 80.0 to 100.0 dinars per 1 euro, corresponding to ΔX_t changing from 100 to 125) delays the payment for about two days, on average. The effect is slightly more pronounced for the RSD than for the EUR loans (3.0 vs. 1.7 additional days, respectively). This can be seen from the predictive margins, shown in Figure 4, for the exchange rate, lagged GDP growth rate, and relative loan size. The differences between the two subsamples of loans are now even more obvious than in the probit model (Figure 2).

Collateral coverage now becomes insignificant for the full sample and for the EUR loans. It remains significant only for the RSD loans. As with the interest rate and the loan currency

TABLE 8
Poisson Regression for Panel Count Data: Beta Coefficients

$DaysPastDue_{i,t}$	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t	0.0799***	0.0683***	0.1197***
	(0.0038)	(0.0035)	(0.0030)
g_{t-1}	–0.0447***	–0.0395***	–0.0236***
	(0.0071)	(0.0079)	(0.0076)
$RelLoanSize_{i,t}$	1.2615***	1.1845***	2.2950***
	(0.2302)	(0.1997)	(0.2841)
$CollateralCov_{i,t}$	0.0006	0.0003	0.0075***
	(0.0009)	(0.0009)	(0.0013)
$RelFirmSize_{i,t}$	0.1621	0.1444	–0.9163
	(0.4832)	(0.4811)	(1.2321)
$InterestRate_i$	0.0160**	0.0008	0.0426***
	(0.0062)	(0.0212)	(0.0065)
$Region_{i,t}$	0.0862	0.1182	0.2309**
	(0.0849)	(0.1097)	(0.0956)
$Relationship_{i,t}$	–0.4572	–0.7090*	1.3219
	(0.4156)	(0.4254)	(0.9953)
$NetExporter_{i,t}$	–0.3016***	–0.3686***	–0.0021
	(0.0983)	(0.1248)	(0.1490)
$BothCurr_{i,t}$	–0.2500***	–0.2065*	–0.2515***
	(0.0878)	(0.1095)	(0.0888)
$LoanEUR_i$	–0.4829***		
	(0.1028)		
Observations	16,279	9,203	7,076
Wald χ^2	2,191.50	1629.21	2570.69
Pseudo-R^2	0.3572	0.3134	0.4981

Notes: Clustered standard errors are given in parentheses. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance levels, respectively.

dummy, this may again be related to liquidity issues of the firms that borrow in the local currency. A similar change can be seen for the regional dummy. The major difference between the results of the probit model and the Poisson regression is the significance of the exporting status of the firms for the EUR loans in the latter case. The beta coefficients are negative, showing that net exporters that borrowed in EUR, on average, make their loan payments sooner than net importers that borrowed in EUR. This creates a significant difference in the mean number of days past due. However, the late payments resulting from exporter/importer status are, on average, not sufficient to trigger loan default, because the beta coefficients in the probit model (Table 6) are insignificant.

We conduct a series of robustness checks to confirm the role of the exchange rate in the default of corporate loans. To control for endogeneity and unobserved heterogeneity bias, we run a conditional Poisson regression with firm fixed effects. The results are presented in Table 9. The three major explanatory variables (exchange rate, lagged GDP growth rate, relative loan size) remain highly significant and maintain their signs.[12] Collateral coverage, the $NetExporter_{i,t}$ dummy, and the $LoanEUR_i$ dummy are no longer significant.

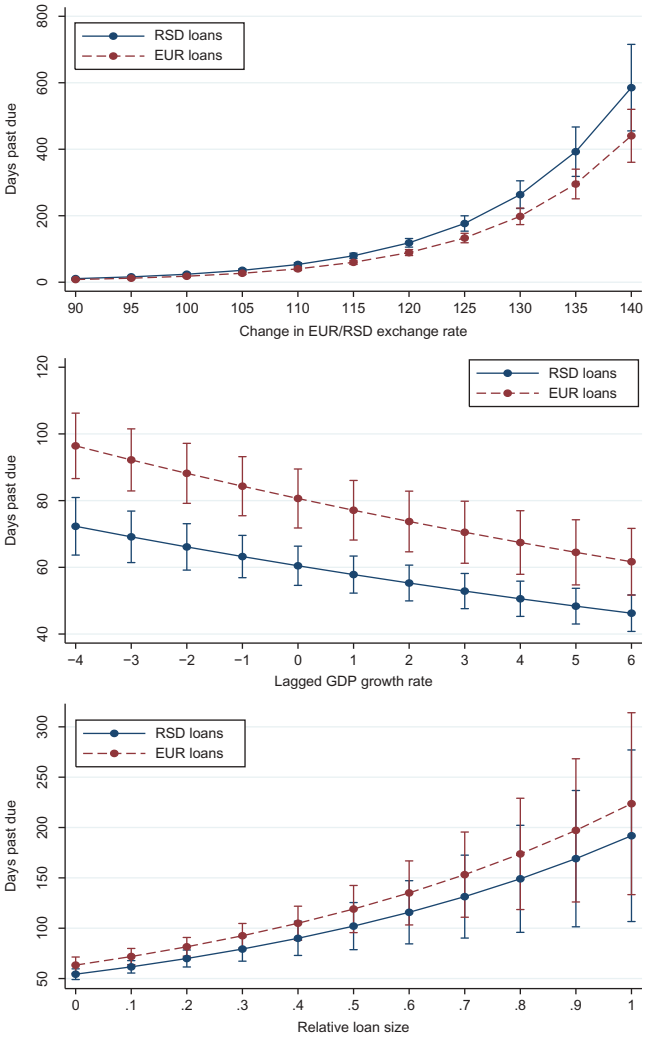

FIGURE 4 Poisson Regression for Panel Count Data: Predictive Margins for Different Levels of Relative Change in EUR/RSD Exchange Rate, Lagged GDP Growth Rate, and Relative Loan Size.

Additionally, we apply an instrumental variable approach in both the probit model for NPLs and the Poisson regression for days past due, using generalized method of moments (Table 10). We use loan age, calculated as the number of months between loan disbursement and observation date, as an instrument for exchange-rate appreciation. The EUR/RSD exchange rate had an increasing trend during the observation period used in our dataset (Figure 1). Since our measure ΔX_t is constructed as an index calculated as a change from date of loan disbursement to date of portfolio observation, it is intuitive that it will highly correlate with loan age. This is indeed the

TABLE 9
Poisson Regression for Panel Count Data: Firm Fixed Effects

$DaysPastDue_{i,t}$	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t	0.0485***	0.0496***	0.0636***
	(0.0049)	(0.0074)	(0.0057)
g_{t-1}	–0.0391***	–0.0251***	–0.0261***
	(0.0065)	(0.0091)	(0.0073)
$RelLoanSize_{i,t}$	1.1047***	1.0221***	1.3597**
	(0.2272)	(0.3270)	(0.4879)
$CollateralCov_{i,t}$	–0.0007	–0.0006	0.0007
	(0.0008)	(0.0011)	(0.0015)
$RelFirmSize_{i,t}$	–49.3438***	–64.6989***	–37.1574**
	(16.8440)	(16.2486)	(16.2503)
$InterestRate_i$	0.0408***	0.1083***	0.0498***
	(0.0061)	(0.0393)	(0.0064)
$Region_{i,t}$	–0.2544*	–0.2873*	
	(0.1468)	(0.1664)	
$Relationship_{i,t}$	–0.8535***	–0.7408***	–5.6585*
	(0.1146)	(0.0979)	(2.9256)
$NetExporter_{i,t}$	–0.1819	–0.1064	–0.0994
	(0.1257)	(0.1247)	(0.1942)
$LoanEUR_i$	–0.1962***		
	(0.0749)		
Observations	6,293	3,697	1,781
Wald χ^2	79,649	130,085	2,491

Notes: Robust standard errors are given in parentheses. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance levels, respectively.

case, as the correlation coefficient between these two variables is equal to 0.79. On the other hand, loan age weakly correlates with number of days past due, making it a good candidate for the instrument. Once again, the three major explanatory variables are highly significant and the interpretation of their effects does not change. The significance of all the other variables is not stable across the models.

To control for neglected or unobserved heterogeneity problems, we apply the KHB procedure of Karlson et al. (2012). The confounding effects are summarized in Table 11 (left panel) for three key determinants of NPLs. Based on the confounding ratios and rescaling factors, we can see that the confounding effects for the exchange rate are very small. Without the confounding, the impact of lagged GDP growth rate is amplified in the full sample and in the subsample of EUR loans, but reduced in the subsample of RSD loans. The impact of relative loan size is also slightly amplified in the reduced model. From the average partial effects (shown in the right panel of Table 11), we can see that any potential confounding does not practically influence the contribution of the exchange rate to an increase in the likelihood of loan default. The marginal contributions of lagged GDP growth rate and relative loan size also differ very little between the reduced model and the full model. The distributional sensitivities of all the key variables are very close to 1 in all three samples.

TABLE 10
Instrumental Variable Approach (loan age used as instrument for exchange-rate appreciation)

	Probit model: $NPL_{i,t}$			*Poisson regression: $DaysPastDue_{i,t}$*		
	Full sample	*EUR loans*	*RSD loans*	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t	0.0766***	0.0616***	0.1329***	0.0996***	0.0887***	0.1580***
	(0.0024)	(0.0025)	(0.0033)	(0.0060)	(0.0056)	(0.0050)
g_{t-1}	–0.0362***	–0.0361***	–0.0434***	–0.0245**	–0.0176	0.0239**
	(0.0038)	(0.0048)	(0.0077)	(0.0106)	(0.0112)	(0.0117)
$RelLoanSize_{i,t}$	1.0486***	0.9576***	1.5791***	1.0169***	0.9983***	2.1231***
	(0.1270)	(0.1278)	(0.2752)	(0.3822)	(0.3120)	(0.4453)
$CollateralCov_{i,t}$	0.0002	0.0002	0.0048***	0.0001	–0.0007	0.0098***
	(0.0005)	(0.0005)	(0.0010)	(0.0010)	(0.0010)	(0.0016)
$RelFirmSize_{i,t}$	0.1059	0.2179	–1.1802	0.3159	0.3956	–1.6869
	(0.3327)	(0.3718)	(1.2875)	(0.5233)	(0.5038)	(1.6747)
$InterestRate_i$	0.0173***	0.0133	0.0323***	0.0330***	0.0301	0.0785***
	(0.0029)	(0.0110)	(0.0033)	(0.0066)	(0.0236)	(0.0074)
$Region_{i,t}$	0.0915**	0.1040*	0.1256**	–0.0885	–0.0705	0.1456
	(0.0427)	(0.0563)	(0.0581)	(0.1014)	(0.1275)	(0.1298)
$Relationship_{i,t}$	0.0593	–0.1114	0.2678	–0.4479	–0.6571	0.8604
	(0.2546)	(0.2957)	(0.4041)	(0.4194)	(0.4349)	(1.0060)
$NetExporter_{i,t}$	0.0783	0.0974	0.0971	–0.2003*	–0.2759**	0.3512**
	(0.0522)	(0.0686)	(0.0730)	(0.1085)	(0.1394)	(0.1657)
$BothCurr_{i,t}$	–0.1029**	–0.0418	–0.1451***	–0.2440**	–0.1985	–0.2055*
	(0.0407)	(0.0553)	(0.0530)	(0.1141)	(0.1333)	(0.1116)
$LoanEUR_i$	–0.3278***			–0.7212***		
	(0.0480)			(0.1225)		
Observations	16,279	9,203	7,076	16,279	9,203	7,076

Notes: Clustered standard errors are given in parentheses, with clustering by individual loan contracts. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance, levels respectively.

CONCLUSION

This article studies the empirical determinants of NPLs by focusing on micro-level data on loans to enterprises in a euroized economy, taking into account both macroeconomic and borrower-specific variables. Using a well-diversified corporate loan portfolio from a Serbian bank in the period from 2008 to 2012, we have identified the following key determinants of nonperformance: the depreciation rate of the local currency with respect to the euro, lagged GDP growth rate, and loan size relative to total assets of the borrower.

The impact of the euro exchange rate may seem peculiar and counterintuitive. The negative influence of the euro exchange rate with respect to the local currency does not seem to be more pronounced for euro-denominated loans. To understand this result, one should bear in mind that the companies in the sample operate in an economy with a high degree of currency substitution and significant pass-through of the euro exchange rate to general price levels. Therefore, exchange-rate risk seems to affect a borrower's ability to repay a particular loan, both directly and indirectly, through its influence on input prices and other nonfinancial liabilities. However, the indirect influence is stronger. By controlling for the exporting activity of each firm, we show

TABLE 11
Probit Model: Confounding Effects and Average Partial Effects for Key Determinants (KHB method)

	Confounding effects			*Average partial effects*		
$NPL_{i,t}$	*Full sample*	*EUR loans*	*RSD loans*	*Full sample*	*EUR loans*	*RSD loans*
ΔX_t						
Reduced model	0.0532***	0.0439***	0.0858***	0.0087***	0.0081***	0.0111***
	(0.0018)	(0.0021)	(0.0035)	(0.0003)	(0.0004)	(0.0004)
Difference	–0.0004	0.0021	–0.0034	–0.0001	0.0004	–0.0004
	(0.0109)	(0.0099)	(0.0701)			
Conf. ratio	0.9919	1.0494	0.9616			
Rescaling factor	1.0179	1.0170	1.0293			
Distributional sens.				1.0094	1.0114	1.0061
g_{t-1}						
Reduced model	–0.0447***	–0.0442***	–0.0574***	–0.0073***	–0.0082***	–0.0074***
	(0.0033)	(0.0045)	(0.0058)	(0.0006)	(0.0009)	(0.0008)
Difference	–0.0070	–0.0012	–0.0207	–0.0012	–0.0002	–0.0027
	(0.0110)	(0.0100)	(0.0702)			
Conf. ratio	1.1866	1.0272	1.5654			
Rescaling factor	1.0371	0.9997	0.9935			
Distributional sens.				1.0284	0.9942	0.9711
$RelLoanSize_{i,t}$						
Reduced model	1.0269***	1.0877***	2.5537***	0.1687***	0.2017***	0.3309***
	(0.1183)	(0.1309)	(0.3033)	(0.0194)	(0.0239)	(0.0387)
Difference	–0.0709	0.0854**	0.7173***	–0.0117	0.0158	0.0930
	(0.0612)	(0.0388)	(0.1268)			
Conf. ratio	0.9354	1.0852	1.3906			
Rescaling factor	0.9759	1.0038	1.0389			
Distributional sens.				0.9677	0.9982	1.0155

Notes: Clustered standard errors are given in parentheses, with clustering by individual loan contracts. The asterisks ***, **, and * indicate 1 percent, 5 percent, and 10 percent significance levels, respectively.

that an increase in the exchange rate does not improve loan performance through the positive effects it may have on the firm's profitability, thus justifying our conclusion. In fact, this result should hold for any economy with structural imbalances, such as those with a current account deficit predominantly financed through external liabilities. Translated to the micro-level, such circumstances are reflected in the net open foreign-currency position of individual borrowers, that is, in an excess of payments over receipts denominated in a foreign currency.

Our results imply that risk-assessment models applied on the level of the individual bank, as well as the banking sector's micro- and macro-prudential regulations, should focus on the individual borrower's overall cash flow structure, rather than *ex-ante* classification by the currency of denomination of an individual loan. Special attention should be paid to the sensitivity of a borrower's input costs to the exchange rate. The results presented in this article may also be relevant for macroeconomic stress testing methodology within the internal capital adequacy assessment process under the Basel regulatory framework. In addition to the usual macroeconomic factors, such as GDP growth rate, interest-rate levels, and inflation, a proper risk-assessment methodology should include the exchange rate as an important driver of credit risk.

Our findings are based on a dataset of loans issued to companies, and it would certainly be interesting to see whether similar results hold for retail loans, since households face somewhat lower euroization of costs. We leave the discussion of this interesting topic for future research.

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Notes

1. We use the term "euroization" by analogy with "dollarization" to describe the local currency substitution effect.
2. The outliers are rare and appear only in the set of explanatory variables. Most likely they originate from misplaced decimal points (e.g., when percentages were used instead of decimals) or from using raw currency units and thousands inconsistently. Typically, they appear as amounts that vary by one or several orders of magnitude from the mean, making detection fairly straightforward. Nevertheless, we have applied the classic Q-test of Dean and Dixon (1951) to verify the elimination formally. Obvious errors in data inputs are mostly of the logical type (e.g., wrong data formats, signs, observations where total assets are smaller than original loan size, etc.).
3. The euro is the most common currency of denomination for loans in Serbia, accounting for 71 percent of the total outstanding amount of loans issued to companies in Serbia, and 82 percent of the total outstanding amount of loans to companies issued by the observed bank at the end of 2012.
4. About 1.4 percent of the total amount lent by banks to companies in Serbia (and 7.3 percent of the total amount lent by the observed bank at the end of 2012) was denominated in Swiss francs.
5. In 2011, the National Bank of Serbia imposed a regulatory measure that implicitly prohibited loans in Swiss francs, following a significant appreciation of the franc with respect to the euro (and consequently, with respect to the Serbian dinar). Since then, all commercial banks have effectively ceased to issue CHF-denominated loans.
6. This is also confirmed by the Andrews and Fair (1988) test.
7. The average collateral coverage for EUR loans is 44.6, while for RSD loans it is only 5.2 percent of the loan size; cf. Table 3(b).
8. Controlling for firm fixed effects, however, results in negative beta coefficients that are in line with this economic intuition (see Table 9).
9. As Table 3(b) shows, the average interest rate for RSD loans is 4.75 percent, with a standard deviation of 8.08 percent. In contrast, EUR loans have an average interest rate of 8.03 percent, but the standard deviation is only 2.69 percent.
10. Since the interaction does not affect the estimation results significantly, the results are not reported, but they are available upon request from the authors.
11. See, for instance, Cameron and Trivedi (2013).

12. The number of observations is now considerably lower than before due to aggregation, given that a firm can have more than one loan. Also, the regional dummy is left out of the estimation for the subsample of RSD loans, since the "within" transformation creates a sample with no variation across *Regioni,t*.

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